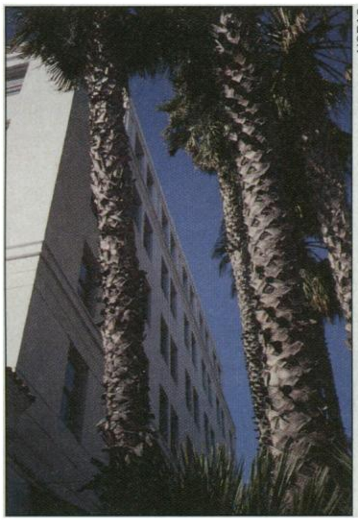
ECOLOGY

Center Seeks Synthesis to Make Ecology More Useful

Ecologists have always prided themselves on their broad view of nature. After all, the basic aim of ecology is to assemble myriad tiny details into coherent pictures of how ecosystems work. But in the late 1980s, University of Minnesota ecologist David Tilman surveyed his field's literature and got a surprise: 70% of all field studies lasted only one to two seasons. "I was amazed and disturbed," he says, and he wondered whether researchers were "getting a biased view of how nature works."

Tilman was hardly alone in his disquiet. About the same time, ecologist Peter Kareiva of the University of Washington had begun to suspect that the spatial scale of much ecological research was "hopelessly inadequate." So he did his own literature search—and found that half of the field experiments in population dynamics were done on plots a meter or less in diameter.

Such findings put numbers to a feeling shared by many influential ecologists at the time: Data from thousands of small studies on everything from predator-prey cycles to soil nitrogen levels were piling up, but too few ecologists were looking at big-picture questions such as how ecosystems respond to disturbances over time, or why some regions are more species-rich than others. And there was no funding for those who wanted to try, recalls Jim Gosz of the University of New Mexico. Now a pioneering center at the University of California, Santa Barbara, has set out to foster some broader views.


NCEAS

Ecology central. The new center has opened in Santa Barbara.

Called the National Center for Ecological Analysis and Synthesis (NCEAS), and funded by the National Science Foundation (NSF) to the tune of $2 million a year for 5 years, the center opened its doors 18 months ago in a leased office suite in downtown Santa Barbara. It is now settling into its unusual mission: organizing small workshops and funding efforts to look at big questions in ecology—without collecting any new data. Proponents believe that lurking in the vast compendia of data ecologists have already assembled are patterns that will shed light on how ecosystems work, as well as help ecologists advise policy-makers facing new and pressing ecological questions. Says Steve Carpenter of the University of Wisconsin, chair of the center's science advisory board, "There are huge databases out there that cost millions to collect, and we can do the value-added work of bringing smart people together to look at what it means for $20,000. This is incredibly cost-effective."

It isn't clear yet whether the center's diffuse and lofty mission will actually lead to concrete progress or truly new insights. But projects are already under way on topics ranging from deep-sea biodiversity to ecological economics. And proponents see creation of the center as an important step in returning ecology to its roots as a synthetic science. "Ecology is undergoing some major changes, and the center is one of the symbols," says Steward Pickett of the Institute of Ecosystem Studies in Millbrook, New York.

Part of the impetus for the new approach came from ecologists eager to take full advantage of new technologies such as remote sensing and massive computing power, which allow integration of huge data sets, recalls Gosz, former division director for environmental biology at NSF. More important, however, was increasing pressure to provide real-world guidance to land managers and policy-makers. At a recent symposium* held to showcase the center's mission, virtually all participants agreed that ecology needs to become a problem-solving discipline. That itself is a "mind-boggling" culture shift, says NCEAS Director Jim Reichman, who took the helm just last fall: "Five years ago, this wouldn't have been mentioned, and 10 years ago it would have been actively opposed."

Back then, the academic mind-set in ecology—and in funding agencies—favored basic questions over applied ones, recalls Carpenter. And intense competition for funding drove ecologists to carve out "narrow, defensible niches" in increasingly specialized subdisciplines. Those subfields—population, community, ecosystem, and landscape ecology, among others—have flourished in the past 25 years, but practitioners publish in separate journals and seldom interacted until recently, notes Gordon Orians of the University of Washington. One result, believes ecologist Jim Brown of the University of New Mexico, is that many researchers have given up trying to answer big questions and instead apply rigorous methods to "small, unimportant problems. … Nobody talks about the laws of ecology anymore the way we did in the 1960s."

Even worse, this fragmented focus makes it difficult to address what managers need to know—broad questions about how ecosystems will respond to disturbances such as habitat fragmentation, climate change, or invasions by exotic species. "When problems such as rapid biodiversity loss became apparent and policy-makers turned to ecology, the emperor appeared to lack clothes," Orians says.

Such problems have been noted before; NSF created the 18-site Long-Term Ecological Research (LTER) network back in 1980 to remedy the short-term focus by studying ecological processes over decades. But the LTERs have been criticized for doing little to actually compare data across sites and look for broad insights (*Science*, 15 October 1993, p. 334).

So, 15 years later, after gathering recommendations from a broad cross section of ecologists, NSF agreed to infuse new money into ecology to create a center to foster synthesis. NCEAS now sponsors a couple of workshops each month and hosts up to 16 postdocs and sabbatical visitors. It also provides high-performance computing resources onsite as well as links to NSF's San Diego Supercomputing Center for integrating large data sets. Two dozen collaborative projects get funding from the center, and it's on the lookout for more. "Think of good, risky ideas and send them in," Carpenter urged the 150 ecologists at the symposium. "We want to see things that are at the edge or over the edge."

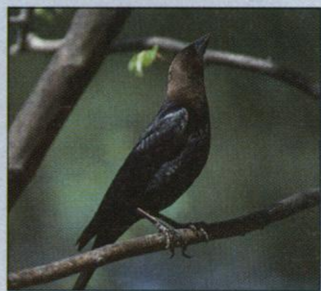
For example, a recent workshop at the center brought together 30 scientists involved in analyzing results from one of the most ambitious synthesis efforts in ecology: the Global Change and Terrestrial Ecosystem (GCTE) project. This massive effort involves 760 scientists and technicians and $33 million worth of research in 41 nations. The goal, says Brian Walker of Australia's Commonwealth Scientific and Industrial Research Organization Division of Wildlife and Ecology, is to predict how the entire terrestrial biosphere will re-

* Synthesis in Ecology: Applications, Opportunities, and Challenges, Santa Barbara, California, 18 to 20 November 1996.

The Rules of Life in a Lumpy World

In the late 1980s, while poring over the results of dozens of ecosystem modeling experiments, University of Florida ecologist C. S. (Buzz) Holling thought he spied a general pattern. The processes that control ecosystems seemed to fall into a hierarchy, varying by 10-fold jumps in scale and timing. For example, the internal controls on the structure and functioning of a spruce forest jump from seasonal population changes among needle-eating insects, to decade-long processes at the canopy level, up to the century-long competition between conifers and hardwoods—with nothing in between. Holling predicted that such jumps should cause a discontinuous pattern in the attributes of ecosystems—"a base lumpiness in the world," as he puts it. In such forests, pulses of seed production, cycles of mammal and bird populations, and fire patterns should all cluster into a small number of cycles ranging from years to several centuries or more. And animals evolving against this lumpy template should echo the pattern in their traits.


C. C. LOCKWOOD/ANIMALS, ANIMALS


PAT CROWE/ANIMALS, ANIMALS

Fair fight? While the endangered red-cockaded woodpecker *(above)* struggles to survive in the Everglades, the similar-sized brown-headed cowbird *(right)* is moving in.

This bold idea has yet to be widely accepted, but Holling's work is a perfect example of the kind of creative, synthetic approach that funders often wouldn't support in the past—and that the new National Center for Ecological Analysis and Synthesis now seeks to foster. Holling's work wasn't funded by the center, but officials featured it at a recent symposium because he synthesizes a broad array of model results and data into big-picture ideas—and because the work may offer practical benefits in monitoring ecosystems. "What Buzz is trying to do is fantastic. It's a superb example of the kinds of things we should be doing," says ecologist Jim Brown of the University of New Mexico.

To test his theory, Holling has analyzed a wide range of available data and discerned an echo of "lumpiness" in traits ranging from body mass to the home range sizes of animals. For example, in an as-yet-unpublished study, he and doctoral candidate Craig Allen found that the 120 native birds of the Everglades fall into 11 distinct clusters of body weight. One group of parakeet-sized species falls in a cluster from 31 to 34 grams; the next weight cluster begins at 37 grams; and few species fall in the gap between 34 and 37 grams. Holling's theory would suggest that those clusters reflect underlying discontinuities in resources such as food types and nest sites.

If so, life should be risky at the edges of the clusters where resources are scarce, especially when ecosystems are being degraded. Sure enough, Holling and Allen found that the Everglades's 20 or so endangered native birds occur disproportionately at the edges of body-weight clusters. And invading species also tend to appear at the edges of clusters. For example, at the upper limit of the 37-to-44-gram cluster, the brown-headed cowbird is invading even as the similar-sized native red-cockaded woodpecker falters. The same pattern holds, Holling says, for endangered and invasive mammals, reptiles, and amphibians of the Everglades. "The edges of lumps are areas of both risk and opportunity," he says.

Many ecologists accept these and other examples of lumpy distributions of traits, although so far few are convinced that the clusters necessarily reflect gaps in the hierarchy of ecosystem processes. But most agree that the idea is worth checking out, in part because if it's true, there may be a practical payoff: Ecologists could monitor edge species to spot early signs of ecosystem degradation. Says Princeton University ecologist Simon Levin, "When you speculate, a lot of times you're going to be wrong, but it's important to generate ideas to test." **–Y.B.**

spond to global change.

The group integrates data from field experiments on every continent in ecosystems ranging from salt marsh to chaparral, as well as from a battery of global vegetation models. And they are finding some surprises. For example, the conventional wisdom from greenhouse and pot studies holds that high CO_2 levels will dramatically boost plant growth. But field studies show that in natural settings, CO_2 boosts plant growth only about half as much as expected. And the group's analysis suggests that as more natural systems are plowed for crops—an activity that releases carbon stored in the soil—terrestrial ecosystems are likely to one day become a net source for CO_2, rather than a sink that helps to slow CO_2's buildup in the atmosphere. That's likely to be big news for climate modelers, notes Walker, because their models now generally assume increasing terrestrial uptake of carbon.

Other efforts supported by the center range from the ecological impacts of hurricanes to the fate of tundra in a warming climate. These varied projects are linked only by the idea of synthesis, which the center defines as "bringing together existing information in order to discover patterns, mechanisms, and interactions that lead to new concepts and models." The definition leaves a lot of room for interpretation. "Synthesis is like motherhood," says ecologist Daniel Simberloff of Florida State University: No one opposes it, but everyone defines it differently.

Given that loose definition, the question now, says Mark Rausher of Duke University, is "whether the community will effectively use the center to its greatest potential." And so far, he gives the center's projects a B-minus.

But New Mexico's Gosz and others are convinced that the center is already making a difference. Just listening to talks on such topics as the "lumpiness" in ecosystems (see sidebar) or human impacts on soil carbon helps to change the mind-set of young investigators, he says. Such projects send the message that "It's okay to do science this way [without collecting primary data]. It's not secondary science."

It will be up to NSF to judge the center's eventual performance, but no formal criteria for gauging success were set out when NCEAS was created. Scott Collins, NSF's technical coordinator for NCEAS, says the agency is now grappling with how to go about what he calls a rather "touchy-feely" task. "We have high hopes for the center," he says. "What we hope comes out of it is a new way of looking at ecology." NCEAS Director Reichman, for one, is unperturbed by the difficulties of measuring his center's accomplishments: "It's sort of like good art: It's hard to define, but I think we'll know it when we see it."

–Yvonne Baskin

Yvonne Baskin is a science writer who divides her time between Bozeman, Montana, and San Diego.